Maine Statewide Bacteria TMDL:2013 Freshwater Addendum
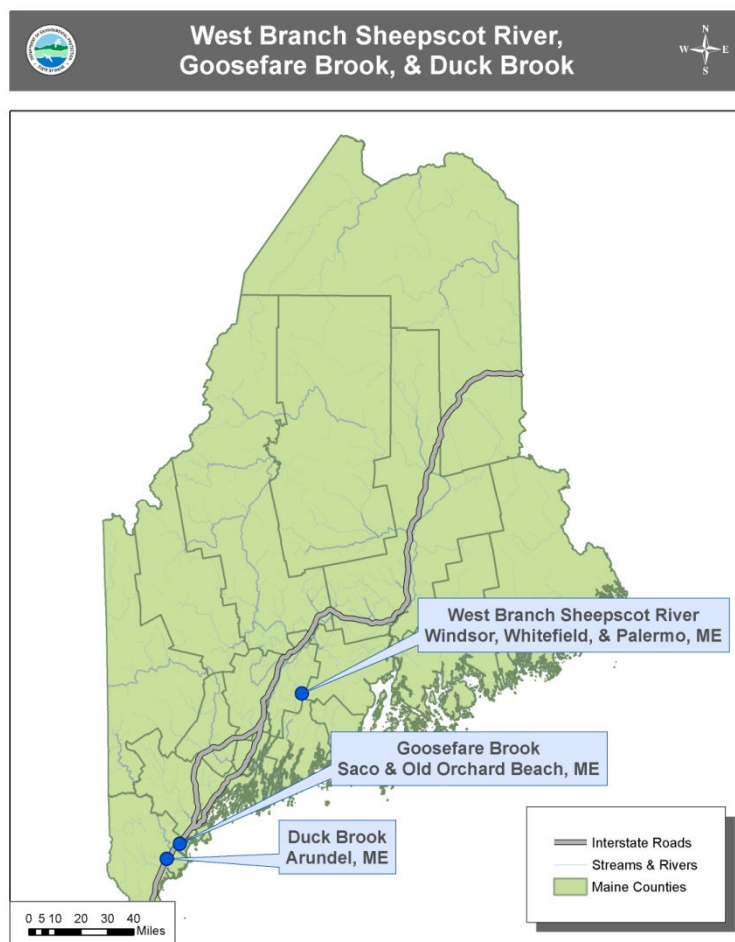
Appendix B: Goosefare Brook Bacteria Sampling Project Reports

Report #: DEPLW-1254
August, 2013

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West Branch Sheepscot River, Goosefare Brook, & Duck Brook

West Branch Sheepscot River
Windsor, Whitefield, & Palermo, ME

Goosefare Brook
Saco & Old Orchard Beach, ME

Duck Brook
Arundel, ME

Interstate Roads
Streams & Rivers
Maine Counties

0 5 10 20 30 40 Miles

Maine Department of Environmental Protection - Created by: KNemmer, August 2013 - Data Sources: MEGIS, MDEP
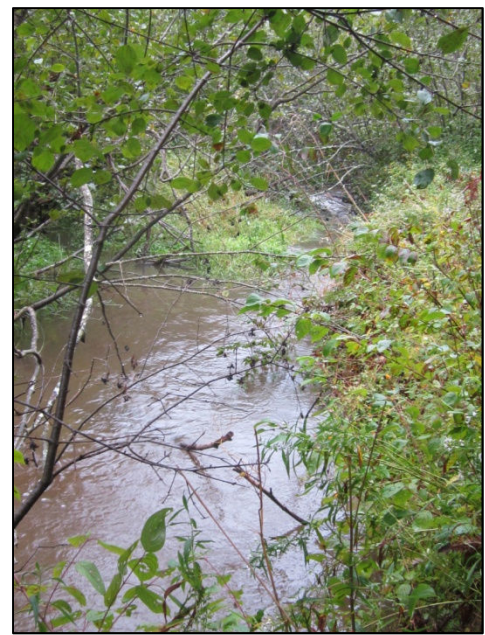
Prepared for:

US EPA New England, Region 1

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION

17 State House Station | Augusta, Maine 04330-0017

Restoration of Streams Impaired by NPS Bacteria

2012 Data Report
Goosefare Brook - Saco, Maine

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Prepared by Pamela Davis Green
Maine Conservation Corps/ AmeriCorps

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION

Protecting Maine's Air, Land and Water

ABSTRACT

The quality of Maine's surface waters, including rivers and streams, is assessed by a number of criteria including designated uses, dissolved oxygen, habitat, aquatic life, and bacteria. Based on these criteria, rivers and streams are assigned a Class of AA, A, B, or C. In freshwaters, the U.S. Environmental Protection Agency (EPA) recommends *Escherichia coli* as the best indicator of health risks associated with recreational waters. *E. coli* is used because it is naturally found in the intestines of all warm-blooded animals and indicates contamination from human, domestic animal, or wildlife fecal waste. A subset of Maine streams impaired by *E. coli* has been selected for study in the Restoration of Streams Impaired by NPS Bacteria project with the goals of: identifying the source of contamination, removal of those sources, and restoration in the form of removal of the stream from Maine's list of impaired waters. Goosefare Brook was included in the study in 2011 becasue of its association with Bear Brook, an impaired subwatersheds. Wetland watersheds were added this year to characterize *E. coli* in natural systems, to assess the impact of wetland bacteria counts on the downstream receiving waters, and to understand what portion of an impaired system might have a natural signature. This year's survey continues to indicate bacterial impairment of Goosefare Brook, and this report outlines suggested actions for addressing potential sources.

INTRODUCTION TO GOOSEFARE BROOK

Goosefare Brook is a Class B stream situated in the city of Saco with a small segment in the town of Old Orchard Beach in York County, Maine (Figure 1). The lower main stem flows for 1.18 miles before it empties into Saco Bay. The Goosefare Brook watershed drains approximately 9.46 square miles of the greater Piscataqua-Presumpscot-Saco watershed. In addition to the main stem, three tributaries are included in this discussion.
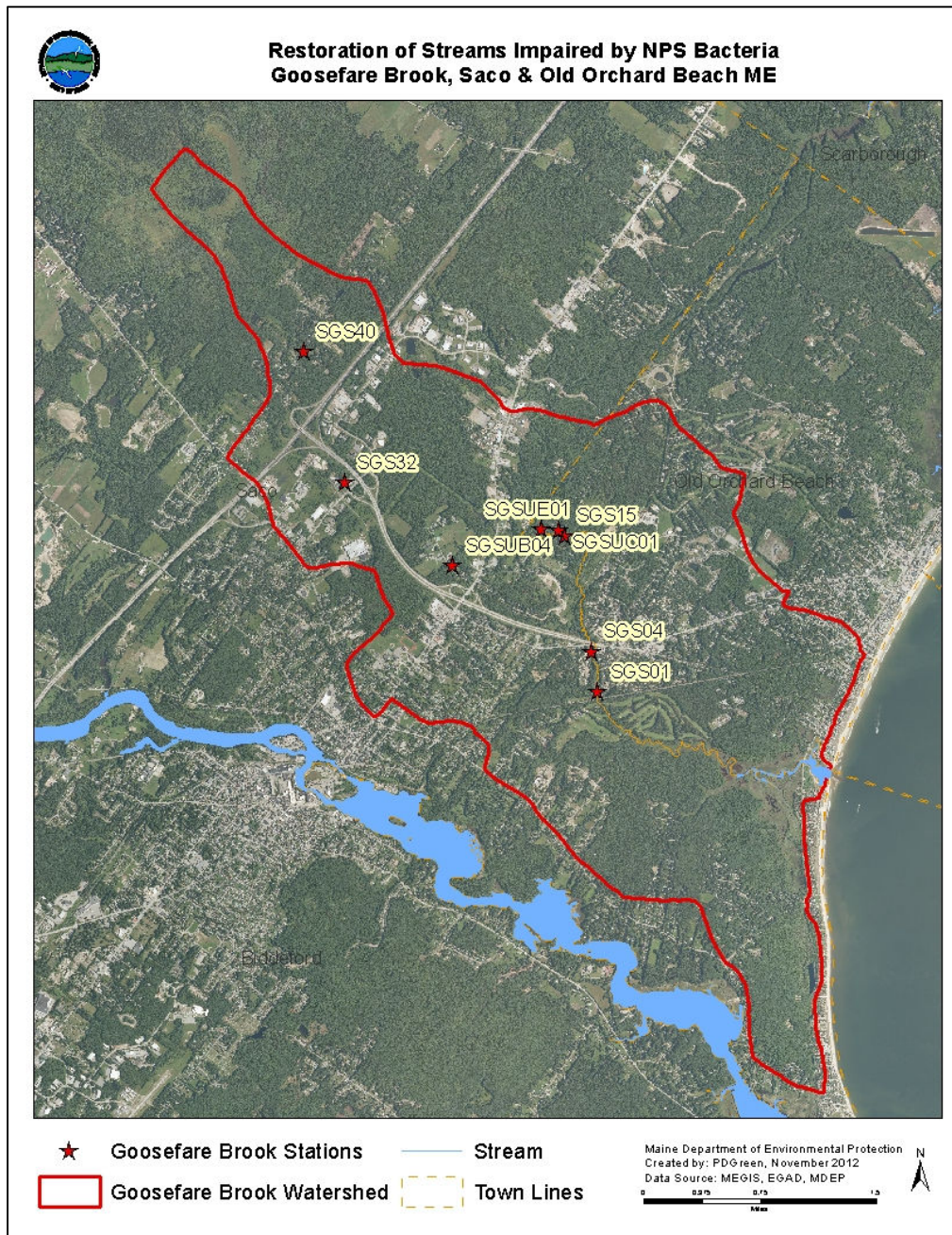

Figure 1. Goosefare Brook flows through a mixed landscape.

The Goosefare Brook watershed is primarily defined by natural drainage divides resulting from topography and elevation contours. Watershed drainage is also subject to development, land use, and impervious surface. The Goosefare Brook watershed has 16.9% impervious surface nested within a land cover mosaic of: 41.9% development including developed open spaces; 44.8% coniferous, deciduous, or mixed forest vegetation; 1.6% agriculture characterized as pastures, crops, or blueberry fields; 7.2% wetland cover; and 4.5% classified as other with herbaceous plants and shrubs (Figure 2).
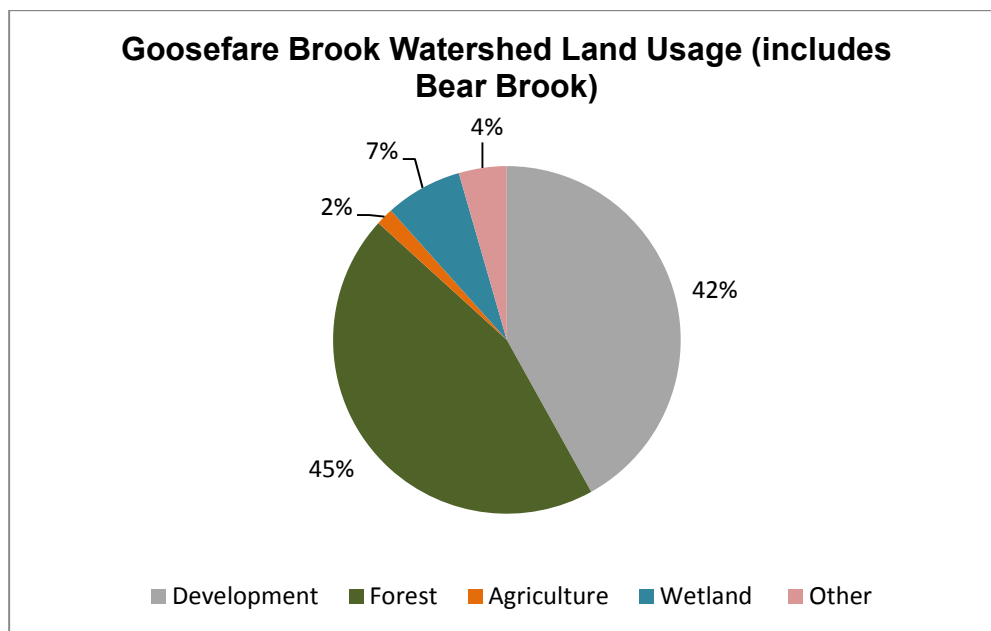

Figure 2. There are a variety of land covers in the Goosefare Brook watershed.

Class B streams in Maine must meet water quality goals for designated uses, habitat characterization, dissolved oxygen content, and numbers of Escherichia coli bacteria. Additionally, discharges into Class B waters must support the aquatic species and biological community that naturally occur there. Goosefare Brook's waters must meet a geometric mean standard (calculated average) of no more than 64 MPN/100 mL of bacteria from human and domestic animal origin, and an instantaneous criteria (one-time reading) of no more than 236 MPN/100 mL *E. coli*; both criteria must be met to attain Maine Water Quality Standard (WQS) in regard to bacteria.

Goosefare Brook was included in the Maine DEP 2004 Integrated Water Quality Monitoring and Assessment Report, also known as the 303(b) report, which lists impaired waters and their cause of impairment. Goosefare Brook was listed for metals, but one of its tributaries, Bear Brook, was listed for *Escherichia coli* bacteria. In 2007, Maine DEP contracted with FB Environmental to assess bacteria levels in a number of streams, including Bear Brook. The FBE study was used to develop the Maine Statewide Bacteria TMDL report which was approved by the U.S. Environmental Protection Agency (EPA) in 2009.

In 2010, Maine initiated the Restoration of Streams Impaired by Non-Point Source Bacteria project, including bacteria impaired streams that were on the 303(d) list and that had been surveyed by FBE. Goosefare Brook was added to the project in 2011 because of its association with Bear Brook and potential to influence downstream beaches and continued to be studied through the 2012 field season. The goals of the Restoration project and for Goosefare Brook are to identify sources of bacteria, eliminate the problems, and remove the stream from the 303(d) list of impaired waters.

METHODS

Sampling stations were established to achieve representative sampling of the watershed (Figure 3). The downstream location (SGS01) on Old Orchard Road was established in 2011 because of its proximity to the site sampled by FBE in 2007. Upstream stations included three that had been surveyed in 2011 (SGS15, SGS32, and SGS40) and added two tributary stations (SGSUC01 and SGSUE01) to explore potential contributions from those previously unsampled waters. Station codes were assigned according to DEP river mile conventions to reflect specific points along Goosefare Brook and its tributaries. For example, SGSUC01 reflects a point 0.1 miles (01) upstream on unnamed tributary C (UC) which flows into Goosefare Brook (GS), then into the southern (S) extent of the Gulf of Maine.
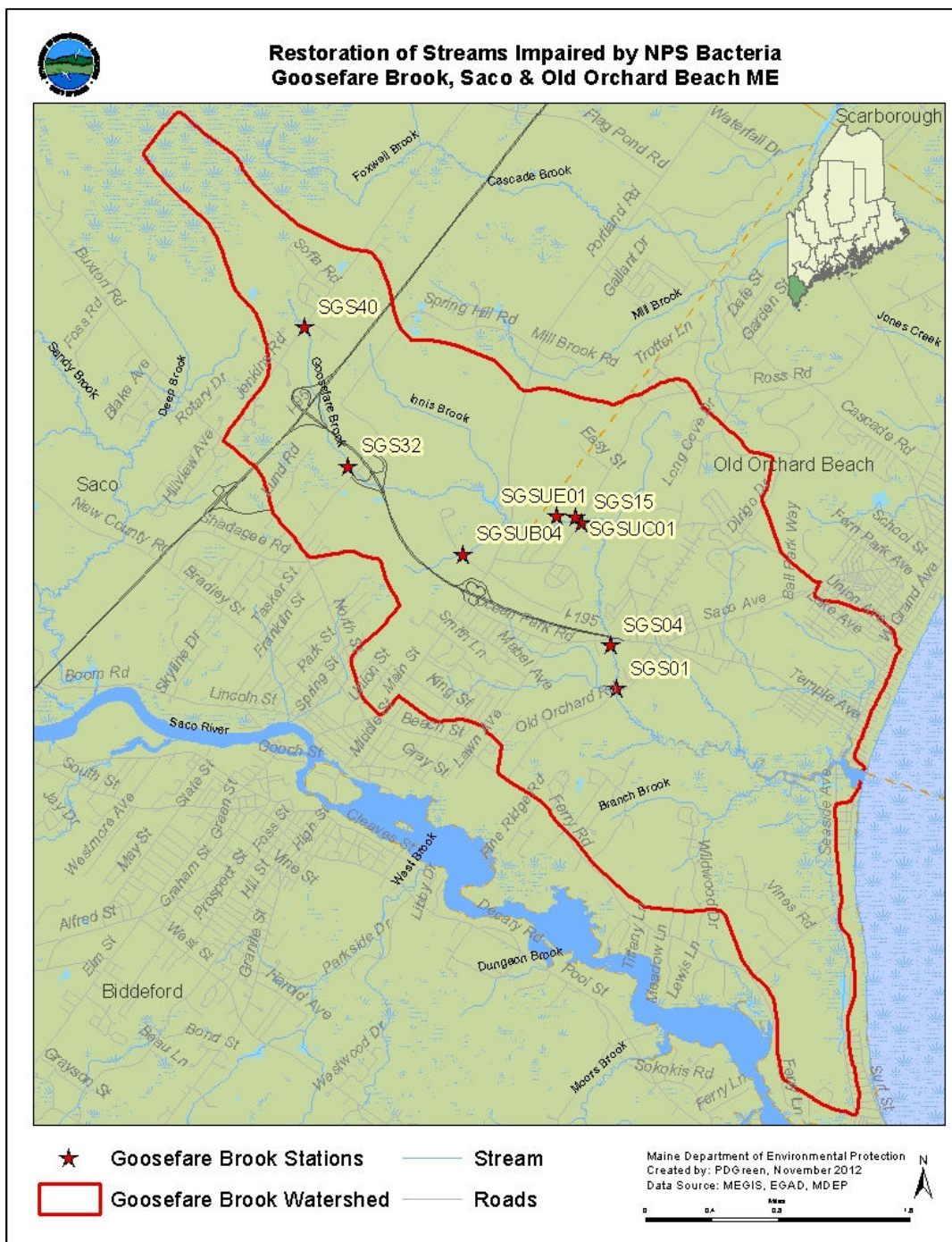
Figure 3. Goosefare Brook 2012 sampling stations included main stem and tributary locations.

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Geographic coordinates were verified using either a Garmin Etrex or a Garmin GPSmap 76CSx hand held GPS unit (Table1). Photographs were taken using a Canon Powershot A2200 pocket camera.

Table 1. Geographic coordinates and description of sampling stations ensures consistent monitoring over time.

SiteCode	Location	Town	UTM_X	UTM_Y	Lat	Long
SGS01	upstream of Old Orchard Rd	Saco	385657	4817729	-70.4144	43.5037
SGS04	downstream of Ocean Park Rd at Old Orchard Beach Family Campground	Saco	385594	4818148	-70.4153	43.5075
SGS15	downstream of Ross Rd	Old Orchard Beach	385314	4819345	-70.4190	43.5182
SGS32	upstream of Industrial Park Way	Saco	383043	4819892	-70.4472	43.5228
SGS40	downstream of Jenkins Rd	Saco	382620	4821247	-70.4528	43.5349
SGSUB04	downstream of Moody St	Saco	384162	4819033	-70.4332	43.5153
SGSUC01	1st trib upstream of Ross Rd	Old Orchard Beach	385261	4819395	-70.4197	43.5187
SGSUE01	2nd trib upstream of Ross Rd	Old Orchard Beach	385074	4819409	-70.4220	43.5188

Land cover analysis was made with ArcGIS version 10.0 using MELCD layers clipped to the Goosefare Brook watershed. The category "Development" includes high_int_dev_mi2, med_int_dev_mi2, low_int_dev_mi2, and open_space_dev_mi2. The category "Forest" includes decid_for_mi2, everg_for_mi2, and mix_for_mi2. The category "Agriculture" includes cult_crops_mi2, past_hay_mi2, and blueberry_mi2. The category "Wetlands" includes wet_for_mi2 and wetland_mi2. The category "Other" is calculated as the watershed area less the combined total of Development, Forest, Agriculture, and Wetlands with percentages calculated for these categories. The percent impervious surface was calculated as imperv_mi2/total_area_mi2.

Precipitation data was obtained through Weather Underground for the Portland, Maine station KPWM. Rainfall was noted as either base flow or storm flow. Base flow conditions are defined as precipitation less than 0.1" during the 24 hours prior to sampling, and storm flow conditions are defined as precipitation 0.1" or greater during the 24 hours prior to sampling.

Meters were used to collect water quality data. An ECtester Plus conductivity pen was used to assess water temperature (°C) and conductivity (µS/cm). A Hach 30d ODO meter was used to measure dissolved oxygen concentration (mg/L), dissolved oxygen saturation (%), water temperature (°C), and to verify the time of data collection (EST). Conductivity was averaged for each station. Conductivity was also assessed as a deviation from the mean of a system so that, in areas of high conductivity due to road treatments or geologic influences, hot spots could be isolated from an otherwise subtle signature.

Water samples were collected from May through September with the goal of including equal base flow and storm flow samples. Routine samples were collected at established stations. From a representative flow, water samples were collected in 100 mL sealed, sterile IDEXX bottles. The water samples were maintained on ice or ice pack in a cooler for no more than eight hours before delivery to the laboratory. Samples were processed using the IDEXX method at the DEP Biological Laboratory or by a different method at the Health and Environmental Testing Laboratory (HETL); both labs are located in Augusta, Maine. At the DEP lab, samples were treated with Colilert, incubated for 24 hours ± 2 hours, and read as MPN/100 mL (Most Probable Number in a 100 mL sample).

Water samples to test for optical brighteners were collected in clean bottles at two sampling stations, SGSBR01 and SGSBRUC03. Samples were maintained in a dark container during

transport to DEP's Southern Maine Regional Office in Portland where Maine Healthy Beaches staff processed them using fluorometric methods. Results were reported in ug/L units. Optical brightener values were averaged for each station. Optical brighteners were also assessed as a deviation from the mean of a system so that, in urban areas with generally high optical brightener values, hot spots could be isolated from an otherwise subtle signature.

Water samples to test for pharmaceutical products were collected in amber glass jars provided by EPA Region 1. Samples were maintained in a cool, dark environment until they were transferred to EPA personnel for transport to and analysis in their laboratories. Results were reported in ng/L units.

RESULTS

Six sampling stations were regularly surveyed from May 10th through September 19th in 2012. A total of two base flow and four storm flow events were sampled. All precipitation data was obtained for the weather station KPWM at Portland, Maine and recorded as inches of rainfall for the day of sampling, for the previous 24 hours, and for the previous 48 hours.

A geometric mean calculation was used to average *E. coli* bacteria instantaneous results (Table 2). The overall geometric mean of 201 MPN/100 mL exceeded Water Quality Standards. The downstream sampling station at Old Orchard Rd (SGS01) had a geometric mean of 279 MPN/100 mL and an exceedance of two of the six instantaneous values which exceeded WQS. The highest geometric mean of 326 MPN/100 mL occurred at SGSUC01 sampling station at 1st tributary upstream of Ross Road while the lowest, 116 MPN/100 mL, was at station SGSUC01 at Industrial Park Way. Most instantaneous exceedances occurred during storm flow except at tributary C which experienced exceedances during base flow.

Table 2. Results of 2012 E. coli bacteria sampling at Goosefare Brook shows exceedances of instantaneous criteria (red), and exceedance of the geometric mean standard (orange).

GOOSEFARE BROOK E.COLI ALL CONDITIONS	Old Orchard Rd	Ross Rd	Ross Rd	Ross Rd	Industrial Park Way	Jenkins Rd	Day Geomean	Overall
	SGS01	SGS15	SGSUC01	SGSUE01	SGS32	SGS40		
Flow & Date	MPN/100 mL	MPN/100 mL	MPN/100 mL	MPN/100 mL	MPN/100 mL	MPN/100 mL	MPN/100 mL	MPN/100 mL
SF: 05/10/2012	770.1	325.5	165.8	218.7	NS	150.0	267	
BF: 06/11/2012	77.6	83.6	107.1	52.0	35.5	29.5	58	
BF: 07/9/2012	122.3	157.6	1732.9	178.9	63.8	41.0	158	
BF: 08/7/2012	131.4	120.1	325.5	73.3	344.8	111.2	156	
BF: 08/09/2012	NS	99.0	91.0	30.0	NS	NS	65	
BF: 09/10/2012	201.4	191.8	178.5	261.3	71.7	59.4	140	
SF: 09/19/2012	2420.0	2420.0	2420.0	1986.4	2420.0	1986.3	2266	
								201
Geometric Mean	279	218	326	157	168	116		

Conductivity was calculated as an average for each sampling station (Table 3). The overall conductivity for the four routinely sampled stations was 390 µS/cm. The downstream sampling station at Bear Brook had a conductivity value of 293 µS/cm. The highest conductivity was at

Coolidge Ave (SGSBRUA07) at 613 µS/cm, and the lowest was at Old Orchard Road (SGSBR01) at 293 µS/cm.

Table 3. Conductivity values were highest at the downstream station, the Ross Road sites, and at the Park & Ride.

CONDUCTIVITY ALL CONDITIONS	SGS01	SGS15	SGSUC01	SGSUE01	SGS32	SGS40
Flow & Date	µS/cm	µS/cm	µS/cm	µS/cm	µS/cm	µS/cm
SF: 05/10/2012	87.5	99	25	50.6	NS	16
BF: 06/11/2012	NS	NS	NS	86.6	NS	NS
BF: 07/9/2012	344	489	113	863	450	128
BF: 08/7/2012	352	519	149	792	521	133
BF: 08/09/2012	NS	NS	NS	NS	541	112
BF: 09/10/2012	398	521	135	733	NS	NS
SF: 09/19/2012	300	465.5	112.5	197.5	375	89
Average	296	419	107	454	472	96

Conductivity values were assessed based on their deviation from a system mean, using an average of Goosefare Brook main stem conductivity values to establish a system mean (Table 4). A deviation from the mean of all Goosefare Brook conductivity was also calculated with the Ross Road (SGS15) and Industrial Park Way (SGS32) stations having highest relative conductivity. When the two tributaries were assessed as a deviation from the mean of the main stem, tributary E was highest.

Table 4. The Ross Road and Park & Ride sites were relatively higher in conductivity than other main stem sites, and tributary E had higher conductivity than tributary C.

Goosefare Brook - Conductivity	Conductivity (µS/cm)	Deviation from System Mean
SGS01	296	22
SGS04	89	-185
SGS15	419	145
SGS32	472	198
SGS40	96	-178
System Mean (Goosefare Brook main stem)	274	

Goosefare Brook tributaries - Conductivity	Conductivity (µS/cm)	Deviation from System Mean
SGSUC01	107	-167
SGSUE01	454	180
System Mean (Goosefare main stem)	274	

Optical brightener samples were assessed based on their deviation from a system mean, using an average of Goosefare Brook main stem optical brightener values to establish a system mean

(Table 5). There was a deviation from the mean at the Ross Road main stem and the 1st tributary upstream of Ross Road, but the deviation was slight.

Table 5. Optical brightener results suggest human sourced contamination in the Ross Road area.

Goosefare Brook - Optical Brighteners	OB (ug/L)	Deviation from System Mean
SGS01	93.36	-7.29
SGS15	109.90	9.25
SGSUC01	106.60	5.95
SGSUE01	82.70	-17.95
SGS32	93.84	-6.81
SGS40	87.16	-13.49
System Mean (Goosefare Brook including tribs)	100.65	

Conductivity was measured at five of the six sample events. In natural freshwater systems, conductivity is expected to be around 100 µS/cm; elevated values can indicate contamination from industrial processes, road chloride treatments, or sewage. Conductivity was high at all sampling stations except the Jenkins Road station SGS40 (Table 4.)

Source tracking of pharmaceutical products was conducted on two occasions at SGSBR01 on Old Orchard Road and once at SGSBR09 on Locke Street. Other scheduled sampling events were unsuccessful due to lack of collection containers or last minute travel delays. Elevated pharmaceuticals detected included acetaminophen, caffeine, carbamazepine, cotinine, and 1,7-dimethylxanthine (Table 6).

Table 6. Source tracking of pharmaceuticals at SGS01 yielded high values (Surf = surfactants, Acet = Acetaminophen, Aten = Atenolol, Caff = Caffeine, Carb = Carbamazepine, Coti = Cotinne, 1,7-dim = 1,7-dimethylxanthine, Metr = Metropolol. BF = Base Flow. RL = Reporting Limit. ND = Not Detected).

Goosefare Brook - Pharmaceuticals ng/L							
RL = Reporting Limit							
Flow & Date	Acet RL 2.0 ng/L	AtenRL 2.0 ng/L	Caff RL 4.0 ng/L	Carb RL 0.4 ng/L	Coti RL 0.4 ng/L	1,7-dim RL 2.0 ng/L	Metr RL 2.0 ng/L
BF: 06/11/2012	ND	ND	12	0.55	1.3	3.6	ND
BF: 08/7/2012	29	ND	140	0.31	7.3	7.5	ND

An innovative tool for tracking human sources of *E. coli* bacteria is the use of dogs, canine detection units specially trained to sniff out human waste. On August 9, 2012, FB Environmental brought two dogs to assess stream water transported to the dogs in buckets. One of the dogs indicated the presence of human-sourced wastewater at the 1st tributary upstream of Ross Road (Table 7).

Table 7. Human-sourced wastewater was detected by a canine during a special study event.

GOOSEFARE BROOK CANINE DETECTION		Sitting Logan	Barking Sable
Goosefare Brook	SGS15 (1)	Negative	Negative
Goosefare Brook, trib C	SGSUC01 (1)	Positive	Negative
Goosefare Brook, trib E	SGSUE01 (1)	Negative	Negative

DISCUSSION

Sampling protocols were followed for all sampling events as well as the special study with canine detection units. Most samples were collected in the morning or early afternoon with two base and four storm flows represented. Additional sampling during storm flow conditions could yield a better understanding of the source of bacterial contamination. More extensive sampling of pharmaceuticals could help track human sources of bacteria.

In general, this year's bacteria results were consistent with previous results. Goosefare Brook exceeded Maine Water Quality Standards for instantaneous or geometric mean criteria for *E. coli* bacteria. Contamination appears to be fairly widespread with the downstream station on the main stem and the tributaries at Ross Road being the most impaired locations.

Since fecal coliform bacteria live in the intestines of humans and other warm-blooded animals, its detection in natural waters warrants investigation into the source and route of contamination.[1] Potential human sources include: failing septic systems or faulty sewer connections, wastewater treatment plants, 'accidents' during swimming, overboard discharges from boats, or combined sewer overflows (CSO). Potential sources from other warm-blooded animals include: manure, livestock near or in the stream, pet waste, birds, or other wildlife.

Several human sources of Goosefare Brook's bacteria can be considered: there are some municipal sewer systems or combined sewer overflows in the area as well as private subsurface wastewater disposal systems. The waters are not conducive to boating, however, and there are no beaches or likely areas for swimming or water-based recreation. The most likely potential human source of *E. coli* seems to be a failing septic or sewer system in proximity to the stream.

There may be some farms or farm fields in the watershed that could contribute manure runoff or place livestock near or in the stream channel. There are nearby residences that could be a source of pet waste from cats, dogs, or other domestic animals. The woodlands and wetlands along the stream corridor and in the upland watershed could support a diverse and abundant population of birds and wildlife that may contribute to bacteria, either directly or indirectly through surface runoff of fecal material.

E. coli bacteria survive long in moist, muddy waters[2]. Natural habitat along the stream channel and adjacent uplands can influence water quality and the presence *of E. coli* bacteria.

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[1] Bacteria and Water Quality, Chapter 2. USEPA Available from: .http://www.usawaterquality.org/volunteer/ecoli/june2008manual/chpt2_ecoli.pdf. Accessed 29 Sept 2012.
[2] Bacteria and Water Quality. Available from: http://www.usawaterquality.org/volunteer/ecoli/june2008manual/chpt2_ecoli.pdf

Goosefare Brook has 16.9% impervious surfaces in the watershed that, when in close proximity to the stream, can facilitate storm runoff of pollutants, including bacteria, from upland areas into the waters.

The watershed has 44.8% forest cover and there may be small localized patches of timber harvesting; trees intercept rainfall, lessen its impact on the soil below, and maintain cooler temperatures of the soils, ground cover, and waters. Clearing trees and vegetation near the stream channel can results in increased turbidity and temperatures. This could boost bacterial colonization and result in elevated *E. coli* counts.

In Maine, conductivity in natural freshwater systems is usually less than 100 µS/cm. Elevated conductivity values can be related to geology, or they can indicate contamination from industrial processes, road chloride treatments, or sewage. The low conductivity at Jenkins Road provides evidence of natural conditions while the elevated conductivity lower in the watershed could result from more intensive road treatments or from inorganic ions related to human-sourced wastewater.

There has been discussion about whether wetlands serve as a sink or source for *E. coli* bacteria. The Goosefare Brook watershed has 7.2% wetland cover, and this may contribute to fluctuations in *E. coli* counts, but the wetland component of this study suggests a minimal impact. A more thorough analysis is necessary to make a definitive determination.

The extremely high E. coli bacteria coupled with high conductivity suggest human sources of contamination. While the Jenkins Road station follows the trends of a natural wildlife signature illustrated by the wetland study, there seems to be a stronger association of human sources with bacterial impairment in much of the watershed.

RECOMMENDATIONS

Restoration of bacterially impaired stream systems begins with a thorough assessment of potential contamination sources for each known location of high bacteria, understanding that there may be a unique suite of human, domestic animal, or wildlife sources at particular points along a stream or river and that upstream contamination can impact downstream locations.

A systematic investigation of contaminated sites will either reveal a direct human source that can be remediated, suggest human activities that may exacerbate natural wildlife influences, or substantiate that bacterial contamination is solely from wildlife sources and natural processes. Recommendations include:

- In compliance with the established framework of the City of Saco's Illicit Discharge Detection and Elimination Plan (IDDE), investigate public sewer and private septic systems for illicit discharges, malfunctions, or cross connections. Overlay tax maps with bacteria results to pinpoint suspect properties and conduct sanitary surveys of the stream to document pipes, waste matter, or other indications of human fecal material or discharges. Use dye tests, smoke tests, or cameras, when available, to explore

subsurface systems and infrastructures. The homes along the 1st tributary upstream of Ross Road seem like a good place to investigate.

- Assess the impact of domestic animal waste. Survey trail systems that intersect with the stream channel, pastures and agricultural lands where runoff could flow into the stream, and direct exposure of animals in the water.
- Evaluate expansive open areas in the watershed that could impact segments of the stream. Impervious surfaces such as large parking lots, dense residential development, or roadways facilitate urban runoff that may contain pet waste and other surface pollutants. Large parks and trail systems with grass and herbaceous cover off minimal filtration of storm runoff, and timber harvesting can introduce soil sediments into the stream.

Goosefare Brook has a well-documented history of *E. coli* bacterial contamination. Elimination of the problem can be accomplished by determination of the most likely source, the route of entry, and implementing structural improvements or behavioral changes to remove the sources. Continued monitoring of *E. coli* bacteria will document improvements that will improve water quality downstream.

Goosefare/Bear Brook (Saco, Maine)
2011 Report

Prepared by Heather Stukas
Maine Conservation Corps/ AmeriCorps

1. Background

1.1. Goosefare Brook

Goosefare Brook is a Class B stream located in Saco and Old Orchard Beach. It has a length of 6.14 miles and a watershed area of 9.83 square miles. The land use in the watershed is comprised of forested land at 46%, developed land (residential, commercial, roads, etc.) at 44 %, wetlands at 7%, and agricultural at 2% (see Figure 1.1 and Figure 1.2a). Although currently not listed for bacteria impairment, Goosefare Brook is listed for aquatic life violations in Maine's 2010 305(b) report. [3]
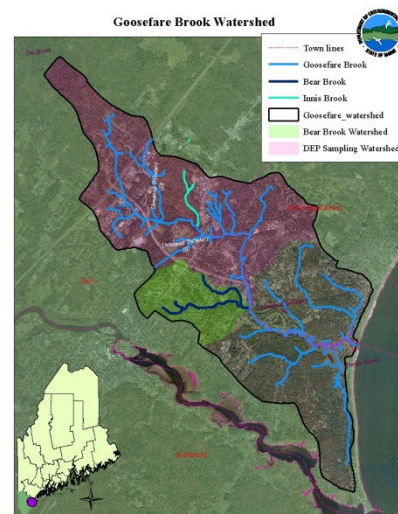

Figure 1. 1: An aerial photo map of Goosefare Brook watershed boundary
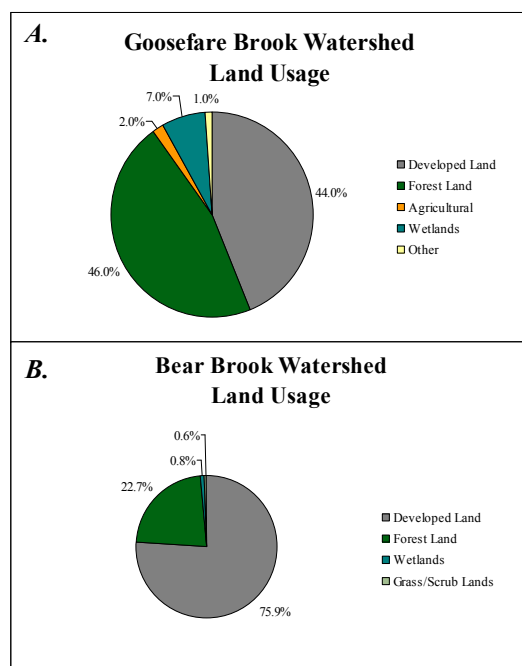
1.2. Bear Brook

Figure 1.2: Watershed land usage specific to Goosefare Brook and Bear Brook.

Bear Brook is tributary to Goosefare Brook. It has a length of 1.2 miles and a watershed area of 0.80 square miles. The watershed is dominated by developed land (residential, commercial, roads, etc.) at 76 %; the remaining watershed is comprised of forested land at 23% and 1% wetlands, grass, and scrub lands (see Figure 1.1 and Figure 1.2b). Bear Brook was one of six streams listed for "bacteria-only" impairment in Maine's 2004 305(b) report, and it remains on the list. [4]

In the spring of 2007, FB Environmental (FBE), under contract to the EPA, sampled Bear Brook above Old Orchard Rd and found a geometric mean of 219 MPN/100mL which exceeds the water quality standard for a Class B stream. To meet State of Maine Class B Standards, a river/stream must attain a geometric mean of 64MPN/100mL and an instantaneous value of 236MPN/100mL.

Non-point source (NPS) pollution is listed as the primary source of bacteria impairment. According to

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[3] (2010). State of Maine Department of Environmental Protection. *Maine Statewide Impervious Cover TMDL: for Aquatic Life-Impaired Waters*

[4] (2008). State of Maine, Department of Environmental Protection. *2008 Integrated Water Quality Monitoring and Assessment Report.*

the FBE study, the most probable sources were malfunctioning wastewater systems and fecal contamination caused by pets. Malfunctioning wastewater systems could be failing/aging systems with leaking pipes and/or obsolete cesspool systems. Fecal contamination occurs when pets and wildlife feces wash into the stream during a rain event.

1.3. Maine DEP & MHB & EPA Team Up

The DEP partnered with the Maine Healthy Beaches Program (MHB) and the Environmental Protection Agency (EPA) during 2011 for a restoration project. MHB and EPA have monitored the local beaches in the watershed extensively and determined there is widespread bacterial contamination. The objective of the partnership is to assist MHB's efforts to clean up Kenney Shores Beach by eliminating sources of bacteria from both Goosefare Brook and its tributary Bear Brook. Additionally, this will enable DEP to meet Clean Water Act goals of removing streams from the 303d list of impaired waters.

2. Method

In accordance with the State of Maine water quality standards, the DEP tested for *Escherichia coli* (*E.coli*) in the freshwater segments of Goosefare Brook and its tributaries **(**see Table 1.1). The MHB tested for enteroccocci in the estuarine/marine segments and optical brighteners[5] on Goosefare Brook and its tributaries. The EPA tested for pharmaceuticals, as part of a source tracking effort, and nutrient samples.

Table 1.1: Below is a list of DEP sampling stations on Goosefare/Bear Brook with a description of their locations.

Segment Name	Site Code	Description of Locations
Goosefare Brook	SGS01	upstream of Old Orchard Rd; next Crossway Christian Church
Goosefare Brook	SGS04	downstream of Ocean Park Rd; next to Old Orchard Beach Family Campground
Goosefare Brook	SGS15	upstream of Ross Rd; on the town line of OOB & Saco
Goosefare Brook	SGS32	upstream of Industrial Park Rd; next to Park and Ride
Goosefare Brook	SGS40	downstream of Jenkins Rd; before Boothbay Lane
Bear Brook	SGSBR01	upstream of Old Orchard Rd; next Crossway Christian Church
Bear Brook	SGSBR06	downstream of Cumberland Ave; below pump station
Bear Brook	SGSBR07	downstream of Cumberland Ave; above pump station
Bear Brook	SGSBR08	upstream of Layayette St; after Grant St
Bear Brook	SGSBR09	downstream of Locke St; intersection of Locke St and Shepard Ave
Bear Brook	SGSBR10	upstream of Locke St; intersection of Locke St and Shepard Ave
Bear Brook-Unnamed Tributary A	SGSBRUA02	downstream of Hogman Ave; before the kennel and horse boarding facility
Bear Brook-Unnamed Tributary A	SGSBRUA07	upstream of Coolidge Ave; towards the middle of the St
Bear Brook-Unnamed Tributary B	SGSBRUB01	upstream of Layayette St; above site SGSBR08 on the right
Bear Brook-Unnamed Tributary C	SGSBRUC01	upstream of Winter St; intersection of Winter St and King St
Innis Brook	SGSIB01	upstream of Main St; diagonal across form Seacoast Rvs (empty lot)
Trout Stream	SGSTS	upstream of Valley Rd; behind BBI Waste in the powerlines
Goosefare Brook-Unnamed Tributary A	SGSUA05	upstream of Old Salt Rd; head southwest on the Amtrack tracks
Goosefare Brook-Unnamed Tributary A	SGSUA08	downstream of Old Orachard Rd; next to Ace Auto
Goosefare Brook-Unnamed Tributary B	SGSUB04	upstream of Moody St; before the Eastern Trail
Goosefare Brook-Unnamed Tributary D	SGSUD06	downstream of Industrial Park Rd; behind Yale Cordage
The descriptions of locations are a supplementary resource; and should be used with a map of the watershed when locating the sampling stations.		

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[5] Optical brighteners are commonly used in commercial or retail products such as clothing detergents, dishwashing, personal care products, etc. to increase the whiteness of materials. After use, these products are typically flushed down the drain; therefore, the presence of optical brighteners in water likely indicates human sources of contamination (i.e.; from an illicit discharge/straight pipe or graywater, or malfunctioning septic system).

Figure 1.3: Maine Department of Environmental Protection sampling stations on Goosefare Brook Watershed.[6]

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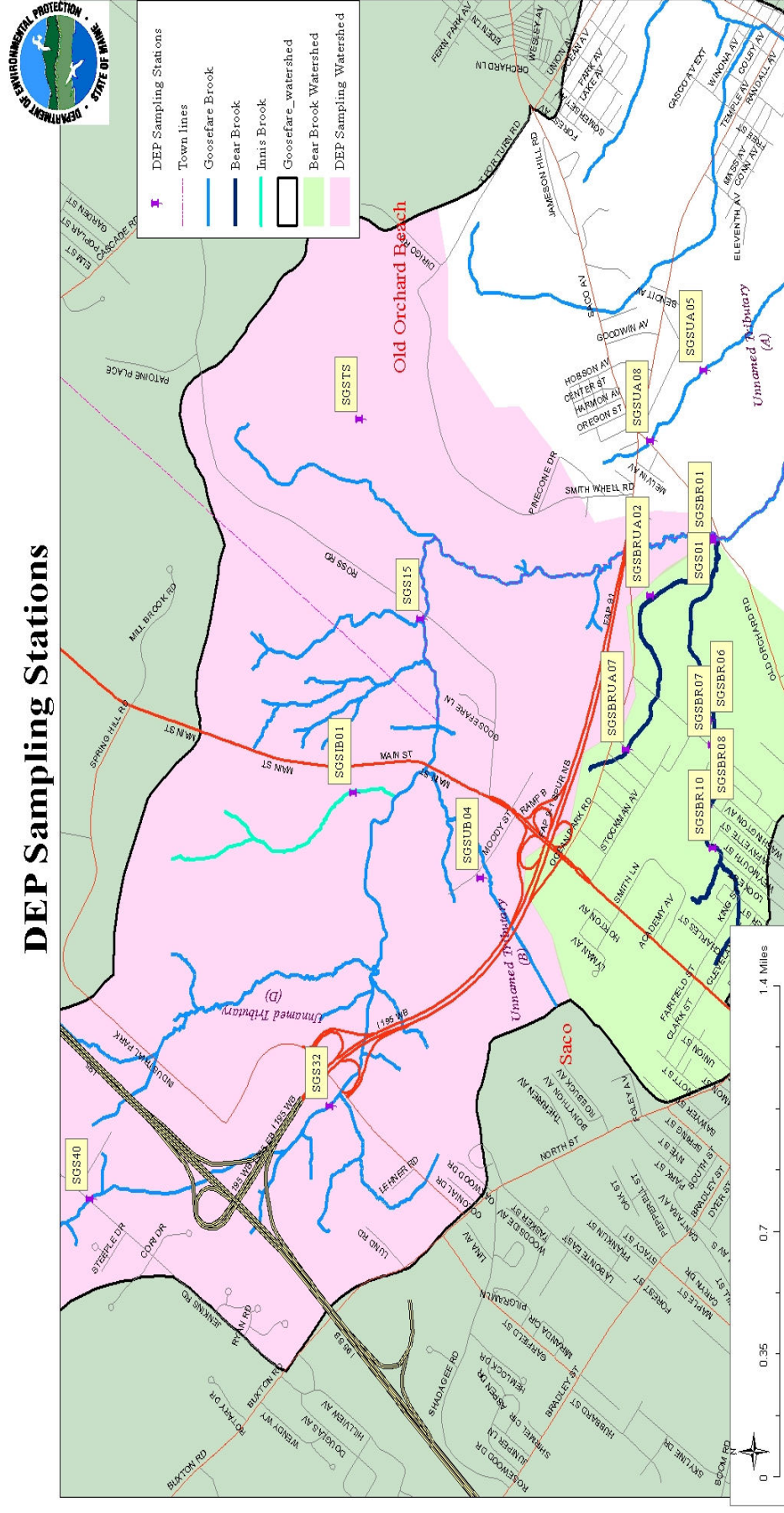
[6] Not all sampling stations from Table 1.1 are displayed; sampling stations that are not displayed were exploratory and not monitored on a regular basis.

3. Data

3.1. E.coli Results on Goosefare Brook and Tributaries (excluding Bear Brook)

The geometric mean for Goosefare Brook at the Old Orchard Rd (GSG01) sampling station is 248/100mL and does not attain Maine geometric mean water quality standard (64/100mL). A compilation of the sampling stations yields an overall geometric mean of 121/100mL. The Moody Rd (GSGUB02) sampling station had the highest geometric mean of 256/100mL, and the Valley Rd (GSGTS) sampling station had the lowest geometric mean of 8/100mL. Two of the sampling stations attain Maine geometric mean quality standard (64/100mL): Valley Rd (GSGTS) and Main St (GSGIB01). The remaining eight stations do not attain.

Table 1.2: Below is a table summary of the 2011 bacteria counts on Goosefare Brook. The original sampling station Old Orchard Rd (SGS01) is outlined in purple.

2011 Bacteria Results Summary of Goosfare Brook and its Tributaries										
	SGS01: Old Orchard Rd. (MPN/100mL)	**SGS04:** Ocean Park Rd (MPN/100mL)	**SGS15:** Ross Rd. (MPN/100mL)	**SGS32:** Industrial Park Rd. (MPN/100mL)	**SGS40:** Jenkins Rd. (MPN/100mL)	**SGSUA05:** Old Salt Rd. (MPN/100mL)	**SGSUA08:** Old Orchard Rd. (MPN/100mL)	**SGSUB04:** Moody Rd. (MPN/100mL)	**SGSIB01:** Main St. (MPN/100mL)	**SGSTS:** Valley Rd. (MPN/100mL)	**Overall** (MPN/100mL)
Date & Flow										
BF: May 24th	99	103	TE	121	44	NS	NS	NS	NS	NS	
BF: May 31st	NS	NS	NS	NS	NS	NS	179	185	29	11	
BF: June 9th	101	79	138	50	921	NS	228	38	28	13	
BF: June 27th	236	248	291	135	124	435	192	135	NS	NS	
BF: July 11th	866	236	141	173	126	133	179	2420	93	3	
BF: August 9th	214	91	64	70	272	179	205	579	NS	NS	
BF: August 23rd	537	727	579	579	770	NS	236	214	NS	NS	
Geometric Mean	248	178	184	134	226	218	202	256	42	8	121
	BF = Base Flow Sample		SF = Base Flow Sample		NF = No Flow		NS = Not Sampled		TE = Testing Error		
	Red = Extremely Exceed Standards			Orange = Significantly Exceed Standards				Yellow = Slightly Exceed Standards			
				Green = Complying with Standards							
	Instantaneous Standard is for a single sampling event; red values indicate an exceedance										

Figure 1.4: Below is a graph summary of the 2011 bacteria counts on Goosefare Brook. The original sampling station Old Orchard Rd (SGS01) is in bottom left hand corner of the graph.

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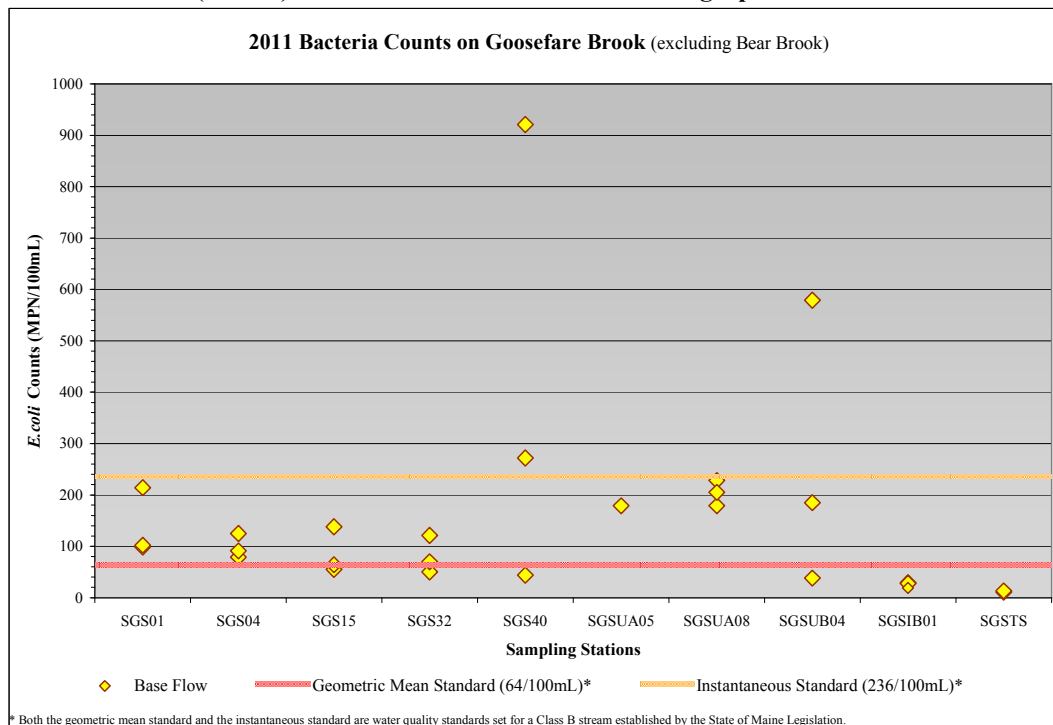
3.2. E.coli Results on Bear Brook

The geometric mean for Bear Brook at the original sampling station is 566/100mL. It does not attain Maine geometric mean water quality standard (64/100mL). A compilation of the sampling stations yields an overall geometric mean of 818/100mL. The Locke St (SGSBR10) sampling station had the highest geometric mean of 1970/100mL, and the Ocean Park Rd (SGSBRUA02) sampling station had the lowest geometric mean of 194/100mL. None of the sampling stations attains water quality standards.

Table 1.3: Below is a table summary of the 2011 bacteria counts on Bear Brook. The original sampling station Old Orchard Rd (SGSBR01) is outlined in purple.

	SGSBR01: Old Orchard Rd. (MPN/100mL)	SGSBR06: Cumberland Ave (MPN/100mL)	SGSBR07: Cumberland Ave (MPN/100mL)	SGSBR08: Layayette St. (MPN/100mL)	SGSBR10: Locke St. (MPN/100mL)	SGSBRUA02: Ocean Park Rd. (MPN/100mL)	SGSBRUA07: Coolidge Ave (MPN/100mL)	Overall (MPN/100mL)
Date & Flow								
BF: May 24th	649	2420	TE	>2420	NS	NS	166	
BF: June 9th	435	1553	921	NS	1986	83	2420	
BF: June 27th	461	866	866	>2420	1120	105	82	
BF: July 11th	816	2420	1553	866	2420	186	921	
BF: August 9th	381	NS	>2420	>2420	>2420	461	1553	
BF: August 23rd	816	NS	>2420	>2420	>2420	364	165	
Geometric Mean	566	1675	1486	1970	1994	194	445	818
	BF = Base Flow Sample		SF = Base Flow Sample		NF = No Flow	NS = Not Sampled		TE = Testing Error
	Red = Extremely Exceed Standards			Orange = Significantly Exceed Standards			Yellow = Slightly Exceed Standards	
				Green = Complying with Standards				
	Instantaneous Standard is for a single sampling event; red values indicate an exceedance							

Figure 1.5: Below is a graph summary of the 2011 bacteria counts on Bear Brook. The original sampling station Old Orchard Rd (SGSBR01) is in bottom left hand corner of the graph.

2011 BacteriaCounts on Bear Brook

◇ Base Flow — Geometric Mean Standard (64/100mL)* — Instantaneous Standard (236/100mL)*

* Both the geometric mean standard and the instantaneous standard are water quality standards set for a Class B stream established by the State of Maine Legislation.

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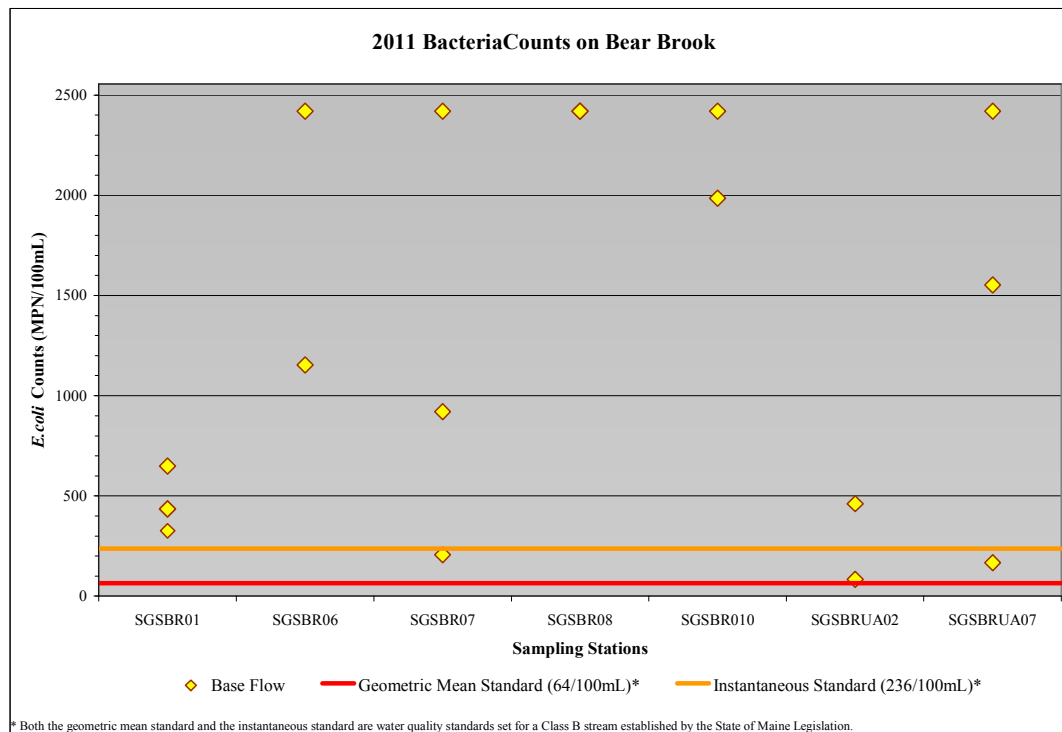
Figure 1.6 A visual representation of the 2011 bacteria counts on Goosefare/Bear Brook.[7]

2011 Bacteria Counts on Goosefare Brook Watershed

2011 Geometric Mean

- 8/100mL
- 42/100mL
- 134/100mL
- 178/100mL
- 184/100mL
- 194/100mL
- 202/100mL
- 218/100mL
- 226/100mL
- 248/100mL
- 256/100mL
- 445/100mL
- 566/100mL
- 1486/100mL
- 1675/100mL
- 1970/100mL
- 1994/100mL

Town lines
Goosefare Brook
Bear Brook
Innis Brook
Goosefare_watershed
Bear Brook Watershed
DEP Sampling Watershed

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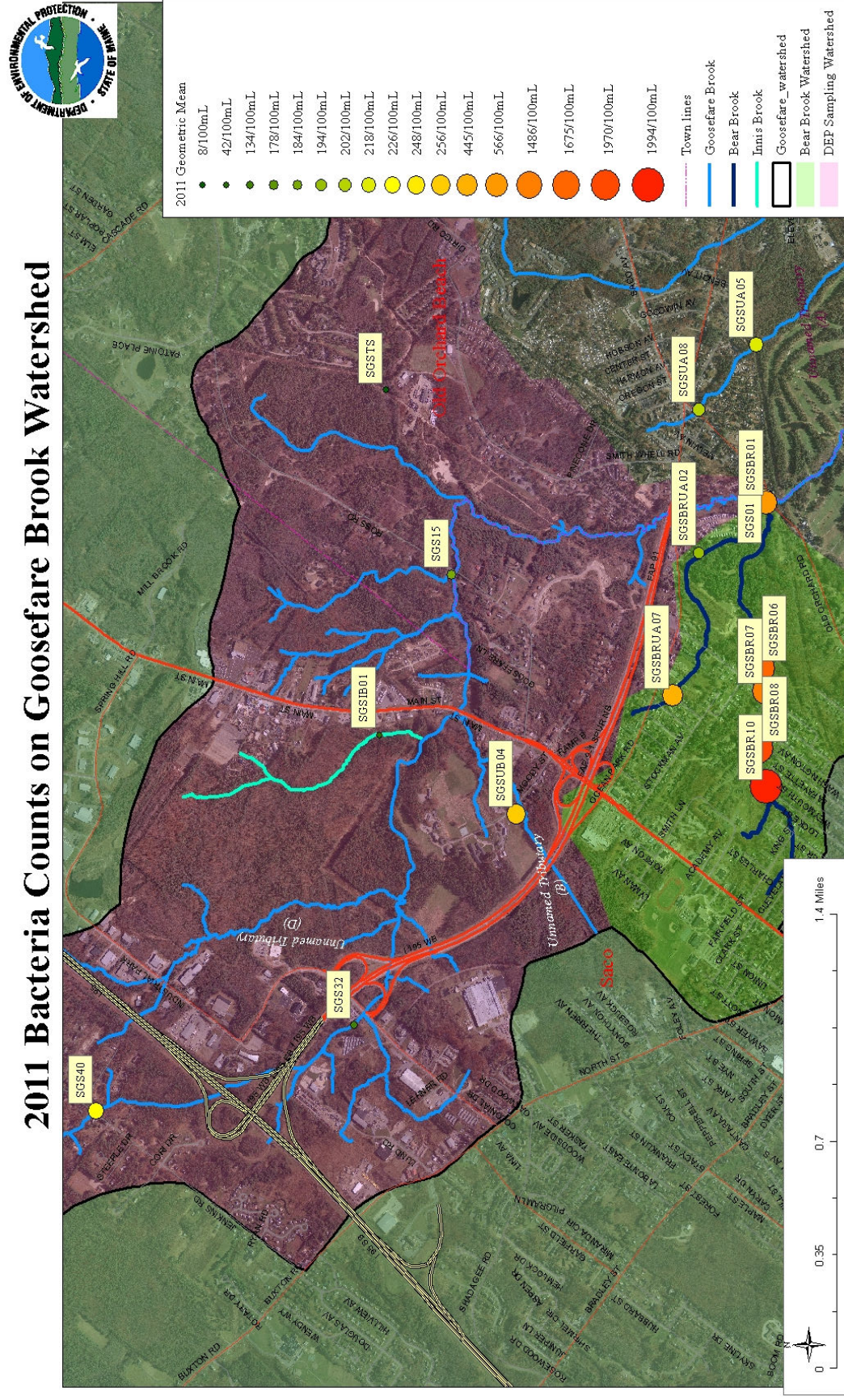
[7] Please note the legend represents the range of geometric means from attainment (in green) to non-attainment (in red) for Class B stream standards, at each site.

3.3. EPA's Pharmaceutical Results

As part of efforts to identify direct human sources, the EPA tested water samples for pharmaceuticals at key sampling stations in both the freshwater and estuarine/marine segments of Goosefare Brook and its tributaries. The pharmaceutical results on the freshwater segments (mainly on Bear Brook) revealed that illicit discharges (such as straight pipes or cross connections between the sewer and stormwater systems) are discharging into the brooks (see Table 1.4).

Table 1.4: The EPA's pharmaceutical results on Goosefare Brook and Bear Brook.

2011 Source Tracking Results on Goosefare Brook and Bear Brook						
	SGS01: Old Orchard Rd. (ng/L)	SGSBR01: Old Orchard Rd. (ng/L)	SGSBR07: Cumberland Ave (ng/L)	SGSBR08: Layayette St. (ng/L)	SGSBR10: Locke St. (ng/L)	SGSBRUB01: Locke St. (ng/L)
BF: May 25th						
1,7-Dimethylxanthine	8.1	16	51	23		
Acetominophen	3.4	3.4	160	2.1		
Atenolol	ND	1.9	13	12		
Caffeine	610	130	490	830		
Carbamazepine	0.64	1.5	2.2	2.1		
Cotinine	2.4	15	11	6.9		
Sulfamethazine	ND	0.52	0.82	ND		
Urobilin	ND	4.8	62	38		
BF: July 11th						
1,7-Dimethylxanthine	4.6	6.5	40		120	38
Acetominophen	ND	2.5	11		3.2	ND
Atenolol	ND	1.2	23		160	66
Caffeine	24	28	230		2600	1400
Carbamazepine	ND	1.6	1.3		0.74	0.44
Cotinine	2.4	6.5	10		12	9.5
Sulfamethazine	ND	ND	ND		ND	0.5
Caffeine = stimulant			Carbamazepine = controls seizures			
1,7-Dimethylxanthine = caffeine breakdown			Cotinine = metabolite of nicotine			
Acetominophen = active ingredient in pain pills			Sulfamethazine = anti-bacterial			
Atenolol = high blood pressure			Urobilin = responsible for urine's yellow color appearance			

4. Discussion

4.1. Goosefare Brook and Tributaries (excluding Bear Brook)

All sampling was done during base flow to determine whether the bacteria contamination was originating from a dry weather source, such as illicit discharges[8], or a wet weather source, such as fecal contaminated runoff (see Table 1.2 and Figure 1.6). In Goosefare Brook, the bacteria contamination is being caused by illicit discharges. Goosefare Brook's 303d list status, for aquatic life and habitat impairments, indicates fecal contamination from storm events may be an issue as well. However, the DEP did not fully evaluate influence of stormwater runoff this season.

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[8] Illicit discharges are leaks or connection failures of sewage pipes.

The bacterial contamination is widespread but restricted to specific segments of the stream. The bacterial contamination extends the entire length of the main stem of Goosefare Brook from the Amtrak railroad tracks on Old Orchard Beach Rd to The Saco Heath on Jenkins Rd. Some tributaries are not bacterially impaired, such as Innis Brook and Trout Stream, while others, such as unnamed tributaries (Tributary A and Tributary B), are impaired. There are also unmapped tributaries that were not monitored because they were overlooked when establishing original stations. The maps in the report are more comprehensive than the ones used at the start of the field season.

A subwatershed analysis is the most logical approach to restore this portion of Goosefare Brook watershed. Two tributaries, and possibly a third, can be ruled out as potential sources for the bacteria pollution. One of the unmapped tributaries, the unnamed tributary (Tributary D) was accidentally sampled because it was originally thought to be the upper section of Innis Brook. The single sample taken at the Industrial Park Rd (GSGUD06) on Tributary D was as low as the Main St (GSGIB01) sampling station on Innis Brook, so the station was dropped. Another tributary could be ruled out quickly because it drains a mainly wooded area. The only obvious human source for Tributary B is the horse stable above the sampling station on Moody Rd (SGSUB04). In this subwatershed, the restoration process may go fairly quickly by identifying and resolving the limited number of potential sources.

The current data is too broad to indicate any specific sources, but suggests that bacteria contamination is caused by illicit discharges. Beyond disease potential, sewerage is carrying excess nutrients and toxics to the stream, which directly impacts the health of aquatic organisms and may contribute to the 2010 aquatic life violations.

4.2. Bear Brook

The bacterial contamination on Bear Brook is being caused by illicit discharges. The bacteria counts recorded this season were extremely high for the dry conditions sampled. Bracket sampling indicates that the bacterial contamination extends to the entire brook, thus increasing the complexity of the problem. The pharmaceutical results for substances, such as caffeine and Tylenol, also extend to the entire brook and corroborate bacteria results.

In order to restore the subwatershed, an intense project needs to be designed and conducted that focuses on stormwater and sewer collections systems. The logical approach is establishing an Illicit Discharge Detection and Elimination (IDDE) Program. The main focus of the IDDE should be examination of the integrity of sewer and stormwater conveyances using current engineering evaluation techniques such as cameras, dyes or smoking testing. In urban settings, topographic watershed boundaries are inadequate, and a comprehensive watershed boundary assessment should be included in the IDDE. The stormwater and sewage collection systems of the urban setting alter the watershed boundaries; for example, what might flow into a stream or river according to topography is actually redirected outside the watershed via pipes or ditches.

In addition to the IDDE, the kennel and horse boarding facility should be inspected above the Hogman Ave (SGSBRUA02) sampling station on the unnamed tributary (or Tributary A). An informal walk through of the facility revealed no obvious issues; however, a more thorough inspection should be conducted. The neighboring land is heavily wooded, and the geometric mean of the Hogman Ave sampling station is relatively consistent with wildlife sources found in

other locations. Surveying the area could better indicate if the bacterial contamination in the area is related or unrelated to the facility.

The current data is too broad to indicate any specific sources, but suggests that bacteria contamination is caused by illicit discharges.

5. Conclusion

The current Goosefare Brook results place it on the Maine List of Impaired Waters, the 303d list, for bacteria impairment. The current results on Bear Brook warrant its retention on the Maine List of Impaired Waters, the 303d list. A project that targets source identification needs to be conducted as the next step to remove Goosefare/Bear Brook from the 303d list, as required under Maine Water Quality Statues.

DEP and the parties responsible for contamination are required to eliminate sources to clean up the brook in a manner that would enable compliance with Maine's water quality standards.

6. Recommendations

6.1. Goosefare Brook and Tributaries (excluding Bear Brook)

- Divide the brook into subwatersheds to facilitate a focused investigative approach
    - Monitor the unknown tributaries
        - Are they attaining or non-attaining?
        - Is unnamed tributary (Tributary D) attaining?
        - Is the horse stable above the Moody Rd (SGSUB04) sampling station on Tributary B the cause of the bacteria problem?
- Conduct more monitoring during storm events
    - Evaluate the influence of fecal contamination
    - Evaluate the impact of stormwater runoff from the impervious surface on the impairment of aquatic life and habitat

6.2. Bear Brook

- Conduct an intense study to identify contamination sources and focus on locating illicit connections
    - Divide the brook into subwatersheds to facilitate a focused investigative approach
    - Establish a Illicit Discharge Detection and Elimination (IDDE) Program for each subwatershed
        - Examine the integrity of sewer conveyances with cameras and other current engineering evaluation techniques
        - Look for households that are illicitly connecting to storm pipe conveyances rather than sewer pipes through dye testing
- Conduct more monitoring during storm events
    - Evaluate the influence of fecal contamination
    - Evaluate the impact of stormwater runoff from the impervious surface on the impairment of aquatic life and habitat